Local biologies, leaky things, and the chemical infrastructure of global health

LOCAL BIOLOGIES, LEAKY THINGS, AND THE CHEMICAL INFRASTRUCTURE OF GLOBAL HEALTH

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This article examines how two chemicals are woven into the infrastructure of global health, and into the social lives of health workers in urban Nicaragua. One chemical is temephos, an organophosphate used to control mosquitoes. The other is chlorine-based products, used to disinfect surfaces and water. While global health projects tend to treat these chemicals as *stable objects*, there are three ways in which they might be understood as *leaky things*, implicated in fluid social interactions. First, global health chemicals are tracked through rigid accounting, but due to *numerical* leakages, they become vehicles for fashioning new forms of concern. Second chemicals leak *structurally*. They can be dissolved and reproduced at a molecular level, though that dissolution is never absolute, and that reproduction is not everywhere the same. Third, chemicals leak in a *sensory* fashion. Sensory interactions with chemicals produce an entanglement of knowledge about bodies and environments.

Keywords: aesthetics, community health workers, dengue, environmental health, mosquitoes

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Media Teaser

Chemicals used in global health interventions have unexpected social, bodily, and environmental effects. Understanding these effects has important implications for mosquito-borne disease and microbial control, including the recent Zika virus outbreak.

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"El abate me pica." "The *abate* hurts me." "The abate gives me a rash." "The abate makes my head ache." "The abate gives me nausea so bad I don't want to eat for hours." "The abate makes it hard to think straight, my mind is so clouded."

El abate me pica. I heard accounts like this repeatedly during my fieldwork with community health workers (CHWs) in Managua, Nicaragua. Nicaraguan CHWs are on familiar terms with a particular chemical, the organophosphate insecticide temephos. It comes in 25-kilogram sacks of brownish granules. Nicaraguans call it *abate* (pronounced ah-BAH-tay), a hispanization of the trade name Abate, given to it by the chemical giant BASF (Badische Anilin und Soda Fabrik). Temephos chokes insect larvae in the water where they hatch, and it is a World Health Organization (WHO)-endorsed first line of defense against the *Aedes aegypti* mosquitoes that transmit dengue, chikungunya and Zika virus among humans.

There are several ways to use temephos. It can be dissolved and sprayed through a tube connected to a rucksack tank. It can be released over large bodies of water from aircraft. In Nicaragua, the most common delivery device is the human hand. *Aedes aegypti* is a domestic, urban mosquito. It lays its eggs in the tiniest of water features: flower pots, tubs, and old tires. Curbing its propagation requires an intimate mode of attack. In regularly scheduled *abatización* campaigns, groups of CHWs visit houses and eliminate mosquito breeding sites by slipping the granules into puddles, sinks, and pools, as well as upturned coconut shells and empty cartons.

In 2008, after several months observing abatización campaigns, I attended a public event in Managua marking the 50th anniversary of the founding of the Nicaraguan Health Ministry's vector-borne disease division, which coordinates all mosquito control efforts. The event included several scientific exhibit booths, including one on abate and other insecticides. When I visited the abate booth, I could not help asking the woman who was running it about the safety of

the chemical. "*El abate les pica*," I explained, mentioning the rashes, the nausea, and the headaches. The woman at the booth assured me that the chemical, as used in Nicaragua, met "international norms and regulations." If the health workers used it properly, then it was safe for them, safe for householders, and lethal for mosquitoes.

This article began as an investigation into the paradox that those on the frontlines of global health campaigns against mosquitoes are vulnerable to chronic, low-dose chemical exposure. During the 2015-2016 Zika virus outbreak, concern about the role of chemicals in global health made international headlines. Rumors that women who ingested water that contained larvicides used against *Ae.aegypti* in Brazil may have given birth to children with microcephaly were countered by official appeals to global safety regulations (Jacobs 2016).

Nicaraguan *abatización* is one of scores of chemical disturbances that constitute what I call, adopting a term from environmental historian Michelle Murphy (2013), the 'chemical infrastructure' of global health. Here, I define global health as the complex of biomedical experimentation, humanitarian intervention, and training that has been brought to bear against a variety of health concerns, most notably infectious diseases including HIV/AIDS, tuberculosis, malaria, and dengue (Biehl and Petryna 2013; Nichter 2008). Many of those who practice and advocate for global health tend to imagine health as a universal human right. They view pandemic disease as an encompassing threat to economic security and traditional state-centric political orders, as well as individual wellbeing. Global health interventions tend to presume not only that human bodies in different places react to pathogens in a reliably similar manner but also that standardized biotechnical interventions—including chemical ones—can be translated across spaces and contexts.

Perhaps the most recognizable components of global health's chemical infrastructure are pharmaceutical. Particular forms of social difference shape the usage, meaning, and even biological efficacy of therapeutic drugs, from antibiotics to antiretrovirals (Peterson 2014; Koch 2011; Biehl 2007; Sunder Rajan 2006). What look like globally standard treatments reshape rather than obliterate what Margaret Lock terms 'local biologies', how "claims to the biological and social are leveraged within historical, cultural, embodied, and political economic relationships" (Brotherton and Nguyen 2013: 290; Koch 2013; Nguyen 2010; Lock and Nguyen 2010; Lock 1993). Despite global health's universalizing vision, neither bodies nor chemicals behave the same way everywhere.

In this article, I show how in Nicaragua two *non*-pharmaceutical chemicals (*abate*, used to control mosquitoes that transmit dengue, and chlorine-based substances, including the bleach that disinfects surfaces and the gas that disinfects water) figure in global health's chemical infrastructure. Both are meant to prevent rather than treat disease, but both—like pharmaceuticals—are what Andrew Barry (2005: 57) calls "informed materials." They arrive in cities like Managua as components of standardized interventions, but they "have changing properties depending on their associations in an everyday reality." Released into landscapes in the name of global health, these chemicals, too, reshape local biologies. They do this in ways both acute (*abate* and chlorine are efficient killers) and subtle (their effects can take days and even years to manifest themselves). My emphasis here is on the capacity of these substances to 'leak': to decompose into skin and water, as well as to drift from spaces of biomedical control and bureaucratic surveillance to ones of situated social and political interaction. Attention to leakage pushes Lock's insights on local biologies into new territory. As both a metaphor for global health and a discernable process, leakage calls attention not only to the dialectical

production of human and nonhuman bodies and socio-political systems but also to the role played by nonliving things—houses, tools, protocols, standards, and, of course, chemicals themselves—in making and unmaking health.

This article is based on fieldwork I conducted (2006, 2007-2009, 2011) with CHWs, epidemiologists, entomologists and Managua residents involved in Nicaragua's national dengue control campaigns. Initially, I asked how encounters with *Ae. aegypti* mosquitoes shaped notions of health among CHWs and their neighbors. My work entailed following CHWs in their daily mosquito abatement tasks, interviewing Nicaraguan medical experts, and documenting the changing place of mosquitoes in ecologies and popular discourse. Drawing on anthropological theory about human-nonhuman relations, I have argued elsewhere that 'mosquito hunting' not only undermines attempts to globally standardize disease control by engendering locally particular 'publics', but also sparks a historically embedded sense of openness and curiosity about the nonhuman world (Kelly and Lezaun 2015; Nading 2014, 2012). At the ground level, ethnographic attention to mosquito control underscores the profusion of organic life that lies within urban infrastructures.

In this article, I build on that research to ask how inorganic chemicals mediate between humans and mosquitoes, as well as between humans another living beings of health concern, including mosquitoes, the target of abate interventions, and microbes, for which chlorine-based products are a well-known prophylactic. While most mosquito populations, as I explain below, remain stubbornly 'local', chemicals traverse national, institutional, and species boundaries in important ways, revealing some of the unintended biological and social consequences of global initiatives like the ongoing fight against *Ae. aegypti.* The recent emergence of Zika in the Americas testifies to the need for this kind of analysis. In addition to ethnographic narratives

gleaned from work alongside and interviews with CHWs, I critically examine scientific studies of mosquito ecology, industry and WHO protocols for abate and chlorine usage, and the particular histories of abate and chlorine-based substances. I aim to highlight the disparate temporal and spatial scales at which global health operates.

For Murphy, a defining feature of chemical infrastructures is that they "are spatially and temporally extensive" (2013: 1). Indeed, industrial and consumer chemicals populate global health's present as well as its past. Substances such as DDT and Paris Green figured heavily in pre-and post-World War II international health (Carter 2012; Packard 2007; Mitchell 2002; Brown 1997). By the 1960s, highly toxic chemicals were at the forefront of worldwide malaria and yellow fever eradication programs. In rhetoric and practice, these midcentury approaches to infectious disease relied on a view of insect vectors, pathogens, and chemicals as stable objects, pitched in atomistic conflict. Contemporary global health taglines, especially those aimed at vector-borne disease ('end malaria', 'eradicate guinea worm', 'stop dengue'), show little shift in this objective view.

The stories I tell here about Nicaraguan health workers and their encounters with abate and chlorine, by contrast, support a view of health (global or otherwise) as constituted not of stable objects in atomistic conflict, but of *leaky things*, implicated in fluid interactions. As Tim Ingold has suggested, what distinguishes 'things' from 'objects' is that whereas objects are discrete and uniform, "things leak, forever discharging through the surfaces that form temporarily around them" (2010: 4; Hodder 2014). Again, global health's chemical history provides a rough guide. In the 1970s, DDT's primacy in mosquito control strategies was undone due to its devastating effects on wildlife and landscapes. DDT and other industrial chemicals have long afterlives, leaching into soils and bodies with harmful effects on reproduction and

cognition (Fortun 2012; Murphy 2013). Yet given that chemicals (including DDT) remain key nodes in global health infrastructure, from dengue control to clinical trials, it seems worth asking how their toxicity and molecular instability figure in local biologies.

While abate and chlorine leak in the material sense that Ingold and others describe, I want to call attention to leakage in a second, more social sense. I identify three ways in which, following Barry (2005), changing chemical and social structures 'inform' one another. First, even though Nicaraguan health workers' engagement with abate and chlorine is closely monitored through strict bureaucratic enumeration and thereby integrated into a system of biopolitical surveillance, a kind of *numerical* leakage occurs. As chemicals disappear into bodies and houses, surveillance seeps into social concern. In Managua, global health chemicals have become incorporated not only into the landscape but also into gender relations, bodily care, and neighborhood economies. Second, like other global technologies, abate and chlorine-based substances leak structurally. Their value to global health is that they can be broken down, molecule by molecule, and reproduced in a variety of settings, but the Nicaraguan material I present illustrates that that breakdown is never absolute, nor is that reproduction everywhere the same (Woolgar and Lezaun 2013; Law and Mol 2001). Third, abate and chlorine, constantly off-gassing and dissolving, percolate through bodies via olfactory and tactile pathways, revealing sensory leakages that are often overlooked in both the practice of global health and critical analysis of it.

LOCAL BIOLOGIES AND INFRASTRUCTURES

Chemical encounters are key to the formation of the contemporary Nicaraguan body politic. Consider some recent news from the sugar mills. Since the late 1990s, an epidemic of chronic

kidney disease has been steadily growing in the region of Chichigalpa. According to La Isla Foundation, 46 percent of all male deaths in Chichigalpa since 2006 have been caused by this epidemic, whose exact origin remains unknown but in which proximity to agro-chemicals may be a factor (Beaubien 2014). Or consider Nemagon. Farmers who worked in banana plantations owned by Standard Fruit Company (now Dole) in the 1960s and 1970s claim that this pesticide, the trade name for Dibromochloropropane, has made them sterile, and it may be at the root of a spate of cancers (Bohme 2014).

These encounters with agricultural chemicals underscore something implicit in the concept of local biologies. Bodies vary materially (and suffer unevenly) due to historical conditions, but bodily biologies are linked in significant ways to extrabodily ecologies. Recent critical attention to the worlds of intestinal microbiota and animal-borne disease—to name just two examples—shows that the zones where body and environment meet form less a rigid barrier than a fluid boundary (Hinchliffe et al. 2013; Benezra, Destefano, and Gordon 2012). This boundary is populated by organic beings but also by inorganic chemicals, including methyl mercury, formaldehyde, Bisphenol A, and Polychlorinated Biphenyls (PCBs) (Langston 2010; Agard-Jones 2014; Shapiro 2015). Studies of antibiotic-resistant bacteria and the uncertain hormonal effects of triclosan-infused soaps underscore the role of chemicals in charting the murky interface between "embodied being and environing world" (Ihde in Haraway 2008: 249; see also Landecker 2015; Orzech and Nichter 2008). Understood through the lens of chemical leakages, local biologies transcend the dialectic between body and society to include granulated chemicals, houses, and bureaucracies.

Evidence for this transcendence can be found in the uses to which people put chlorine bleach during the 2014 Ebola crisis in West Africa. Anxieties about the possible spread of Ebola

through human-human bodily contact led to increased vigilance about the sterilization of hands. Such increased vigilance became evident not only in clinics and hospitals but also in the spaces of daily social interaction. In the wake of the outbreak, activists in the US and in Africa began assembling plastic buckets filled with a five percent bleach solution and strategically placing them at the entrances of homes, churches, and schools to encourage hand sterilization (Snyder 2014; Water Quality & Health Council 2014). Meanwhile, the WHO integrated instructions for hand hygiene into its standard clinical protocols for addressing viral hemorrhagic fevers, but it specifically characterized bleach as an 'emergency' measure that should be phased out (at least in clinics) in favor of soap or alcohol-based rubs (WHO 2014). Here, as in the Nicaraguan chemical encounters I describe below, two "equally valued, but incongruent" obligations leaked into one another (Fortun 2001:13). Bleach, an imperfect solution to an ongoing crisis, enabled 'social distancing' (a priority of emergency interventions) even as the spaces of emergency care became more difficult to distinguish from the spaces of 'normal' social intercourse (Brown and Kelly 2014: 291).

The visible presence of bleach in West African doorways during the Ebola outbreak reflects something I found in my Nicaragua fieldwork, namely, that local biology emerges at points where social and material forms meet—the 'thresholds' where drugs work, or do not, where water systems keep bacteria at bay, or do not, and where the life-cycles of mosquitoes and worms are intentionally disrupted, or not (Koch 2013; Nguyen 2014).

Medical anthropologists have examined hospital, humanitarian, and biosecurity infrastructures and noted the ways in which social categories and subjectivities are reworked at such thresholds (e.g. Street 2014; Redfield 2013; Lakoff and Collier 2008). Attention to the circulation of chemicals through nonclinical public space, however, engages broader

conversations about public forms. While much has been made in science and technology studies of 'thing-power'—how the material volatility of chemicals and other substances has a bearing upon politics and sociality (see Bennett 2010)—in my use of the concept of 'leakage', I aim to highlight the ways in which chemicals, like other forms of infrastructure such as pipes, electrical grids, roads, and dams, act as mediators. Infrastructures, as spaces where natural and cultural forms are 'transfigured', are always prone to leakage (Gaonkar and Povinelli 2003; Bowker and Star 1999; Helmreich 2011; Carse 2012; Zeiderman 2014). How people deal with leakages tells us something about how they imagine possibilities for forging ethical, economic, and political relationships (Anand 2011:557; Larkin 2013).

In her work on chemical infrastructures, Murphy (2013) focuses on the intergenerational and spatial afterlives of those chemicals—examples include pesticides and PCBs—that once promised 'better living' but now act as reminders of the embodied, spatially dispersed legacy of a passing industrial capitalist age:

> [Chemical infrastructures] are distributed and translocal, connecting moments of production and consumption, moving across national borders, traversing scales of life. They are temporally uneven, as some chemicals break down quickly and others refuse to decompose, and thus are present for long durations. Some chemicals cause immediate responses in organisms, others provoke effects that take generations to see, as they slowly injure organisms, ecologies, or even planetary atmospheres (Murphy 2013: 1).

In this post-industrial afterlife, questions about health tend most often to enter the human-chemical story. In my accounts of the numerical, structural, and sensory leakages of abate and chlorine through urban Nicaragua's bodies and landscapes, however, I use the idea of a chemical infrastructure to situate people's engagements with those substances whose role in producing

states of human health is primary (and supposedly positive), rather than secondary (and largely negative). These substances also traverse species borders; they, too, live spatially and temporally extensive lives and afterlives. I turn now to those accounts.

NUMERICAL LEAKAGE

In Nicaragua, as in other dengue endemic areas, the application of abate is supposed to proceed in a rigid fashion. CHWs receive strict orders about how much of the granulated organophosphate to deliver, and in which spaces. They also receive a small plastic teaspoon that, they are told, can hold about 25 grams of the chemical. A 50-gallon water barrel should receive 25 grams, a flower pot five. Application thus looks like the sprinkling of raw sugar into a teacup. Each local health center receives a quantity of abate from the national health ministry, determined in turn by the yearly allocation of funds for dengue prevention from the Pan American Health Organization (PAHO). For the purposes of the intervention, abate is presumed to have an efficacy of 60 days. This means that if homeowners allow it to remain in their barrels and flower pots, *Ae. aegypti* larvae cannot survive there for that period of time.

As I have described elsewhere, abate is part of a standardized and mobile set of technologies for public health accounting and intervention (Nading 2014). CHWs receive not just the chemical but also worksheets for tracking the number and type of water receptacles into which they have deposited it. They receive maps for navigating neighborhoods—broken up into numbered houses and blocks—and instructions about how to discuss the workings of the chemicals themselves. CHWs must teach themselves and householders how to live with abate and without mosquitoes. In the correct doses, abate should be lethal to mosquitoes and harmless to humans.

A rigid enumeration of spaces, granules, and CHW labor-time is at the heart of the mosquito control project. Such enumeration is globally standardized, both to create commensurability and to regulate action across the dengue-endemic world. In Nicaragua, warnings about the judicious use of abate are a constant theme of CHW trainings. The management of chemicals is closely tied to the management of the laboring bodies of CHWs. In trainings and CHW meetings I attended, there was a strong scent of Taylorism. CHWs were told that the local health center would pay them roughly two US dollars for each day of work. A district of roughly 100,000 residents, spread out over some 10 square miles, needed to be treated in less than one month. To accomplish this goal, each worker should treat about 60 houses, which breaks down to about 8 houses per hour, or 7 to 8 minutes per house, over an 8 hour day, not counting one hour for lunch, which CHWs could purchase using the some of the original two dollars.

As in other industrial settings, these demands led to tension between labor and management. In the community I studied, the work of CHWs was routinely audited by the regional health ministry office. In July 2008, the local chief of entomology received an audit report that caused him alarm. On average, the report claimed, the CHWs were only visiting 51 out of the allotted 60 homes. "I don't understand why this round of *abatizacion* is less successful than the last one [held in March]," he said, "This time, we have even more *recursos*!" Here, the term *recursos* (lit. resources) referred not to the amount of abate available but to the total number of CHWs at work. In response, the CHWs peppered their managers with stories of contingency. Some homeowners who didn't want their drinking water to stink of abate were, as one CHW put it, "draping themselves" over their storage barrels to prevent treatment. Even when householders were compliant, 60 houses per day seemed unreasonable. "Do they want quality or quantity?"

one CHW asked me after the meeting. "If *abatización* is about dengue control, they should care about quality" (see Nading 2013). Despite these protests, the local managers insisted that continued missed targets would result in fewer *recursos* being allocated for the next round of abatización. True to the industrial logic at play, poor statistical outcomes were signs not of overwork but of inefficiency.

Mosquito control demands that those who use abate conceive of mosquito-killing chemicals (and mosquitoes themselves) as stable, countable objects, but numbers leak. Though PAHO insists that the technique of abate application remains similar across Latin America, it has no specific policy on payment. National authorities are free to devise 'locally appropriate' remuneration, and they do. The CHWs' two dollar-a-day stipend was constantly under threat (Nading 2013). Within the global standards, there is therefore an in-built economic, numerical flexibility, or leakage. This is an example of how the creation and maintenance of global health infrastructure constitutes a form of biopolitics. It demands particular dispositions both of the technicians who manage it and of the patients and publics who theoretically benefit from that management (Foucault 1990; Lakoff and Collier 2008). Accounting by numbers is supposed to create commensurability, but numbers leak: they can divide as well as unite, and they lay risk atop risk (Landecker 2015; Muehlmann 2012).

Ideas about the 'locality' of biology are also central to medical entomology. Overuse of abate is expensive, and it can also lead to insect resistance. The tolerance of insect larvae to abate varies from place to place, and the medical entomological literature is filled with papers that document tests of insect tolerance to poisons. These tests nearly all refer to mosquito populations associated with particular locations (i.e. cities or regions) (see, e.g. Hemingway and Ranson 2000). 'Local' populations of *Ae. aegypti* are differently able to 'detoxify' themselves

after exposure to abate, depending upon the history of chemical interventions in the places where they have reproduced. In her account of antibiotic resistance in the United States, Hannah Landecker (2015) shows how the biological makeup of resistant bacteria contains a history of biopolitical and risk management strategies. A set of temporalities also appears embedded in the biology of mosquitoes. Laboratory experiments on insecticide tolerance attempt both to recreate past developmental processes and to quantitatively predict how such processes might proceed in the future. Entomologists interested in the mechanisms of detoxification expose generation after generation of wild-caught mosquitoes to abate and other chemicals in order to observe the metabolic changes that result in tolerance. Such work produces artificially tolerant populations of experimental (i.e. no longer wild) mosquitoes that represent potential populations of free-ranging ones. The descendants of 'wild' mosquitoes become experimental creatures. The publication and application of such experiments, which enumerate time-to-tolerance at different levels of exposure, is intended to lead to better theoretical models about chemical-bodily interface at the level of the insect. Biopolitics here takes root at the molecular level of insect resistance (Rabinow and Rose 2006).

The variability of detoxification rates reveals not only a numerical leakage but a temporal one (Barad 2007). For global health planners, abate is component of a packaged dengue intervention model. The chemical intervention is one of a set of schemas for understanding how dengue epidemics occur and how they might be controlled. Others include mosquito life-cycle models, ideas about signs and symptoms, and treatment algorithms. When the Nicaraguan Ministry of Health or analogous actors implement the models to change landscapes, or when entomologists test control regimes against wild mosquito populations, future visions of local biology leak into contemporary ones.

The labor of chemical applicators in Nicaragua and elsewhere is bureaucratically managed not necessarily because of concerns about human health but because of predictive models about mosquito evolution. For CHWs in Nicaragua, the insistence on accountability by ministry officials is offset by an absence of protective equipment. The number of gloves, masks, and other similar tools distributed to CHWs along with the abate granules was, over my two years of fieldwork, zero. This lack of protection means that working days end not just in neatly crafted bureaucratic statements, but in nausea, headaches, and irritated skin. This should come as no surprise, since the company that invented abate, BASF, helped develop the chemically similar nerve agents Sarin and VX for the German army during World War II. Abate's chemical makeup contains a history of other forms of would-be world domination, predicated in part upon the eradication of various supposedly sub-human objects.

Even as the capacity of the mosquito body to develop tolerance to organophosphates enables a biopolitical management of public health, then, CHW bodies quickly develop vulnerabilities that threaten that management. In reaction to this, some CHWs take matters (and matter) into their own hands. Some help themselves to in-kind payments—hoarding stashes of abate at the end of the working day and later trading it to neighbors and kin. Some neighbors use this escaped abate not against mosquitoes but against domestic ants or cockroaches. Released into the landscape in this way, abate subverts neat bureaucratic accountings. As it leaks from the biological and epidemiological models of global health and entomology into the social worlds of CHWs, abate percolates from one locality (the health institution) to another (the community economy). The CHWs' worksheets and plastic spoons are part of a suite of value judgments that produce a 'Nicaraguan version' of the disease. The Nicaraguan health ministry develops its own numerical models for the distribution of the chemical—and presumptions about the risk of

mosquitoes developing tolerance—to calibrate payment for services rendered. Meanwhile, CHWs integrate abate into their own calculations about better living, for themselves and the people they live with. Those calculations exceed numbers, but they are nonetheless economic. They involve weighing the chemical's tendency to cause unwelcome bodily effects against its potency as an exchangeable (and effective) household tool. Since they go into the world nearly simultaneously, none of these understandings of the value of chemicals is responsible by itself for shaping local biologies. Yet value judgments, rendered in numbers and relationships, are always constrained by structures—both material and social.

STRUCTURAL LEAKAGE

Leakages occur in the molecular and industrial processes of chemical production and breakdown. Organophosphates are a fairly generic kind of substance, made in various sites around the world and are regulated in a variety of ways. The second entry that appears in a Google search for 'temephos' is the United States Environmental Protection Agency's temephos fact sheet, which states, "Residential risk is not of concern since temephos has no residential use, and its use in mosquito abatement programs does not result in residential exposure" (EPA 2001: 2).[1] The WHO, by contrast, has approved vendors in two countries (Brazil and India) for the production of temephos that can be applied in the residential spaces where most *Ae. aegypti* live and breed. EPA regulations notwithstanding, residential and workplace exposure is a virtually guaranteed element of WHO standards for temephos usage. Those regulations state that "(i)t is also used for mosquito control in potable water" (WHO 2010: 30).

One could trace the path of Nicaragua's abate (a brand called 'Skeeter 1%', made by a subsidiary of Clarke, a company with deep roots in North American mosquito control) back to its

point of origin, which happens to be a Brazilian chemical factory. But such tracings would provide a misleading picture of how the chemical is produced. To understand the production of abate, we cannot limit analysis to the factory floor. The circuits of chemical production are not 'iterative', nested in neat geographical scales, but 'itinerant', moving not from place to place, but through the fluid spaces of bodies, households, and institutions (Ingold 2010: 10). Abate is made and remade—materially and theoretically—in multiple sites by multiple actors (Woolgar and Lezaun 2013; Law and Mol 2001). What Murphy calls "molecular relations"—the forms of structural connection among bodies, environments, and chemicals—"exceed the chain metaphor" often used in social theory to describe how commodities move through spaces (Murphy 2008: 701; cf. Appadurai 1986). Chemicals can be re-produced in a variety of sites in the sense that identical compounds can be made, but efficacy varies depending on social relations and species variations that transcend simple local-global visions of space. A CHW's adverse reaction to abate exposure, for example, does not really constitute a 'global health' event.

This brings us back to chlorine. Chlorine, in the form of sodium hypochlorite, or bleach, can also be produced almost anywhere. According to PAHO protocols, bleach is essential to the management of laboratories, hospitals, and health centers. Guides provide strict instructions for preparation, dilution, and storage (PAHO 2009). Bleach is so integral to the local operations of global health that—unlike abate—the leading organizations state no preference about which company or factory should make it. As long as medical practitioners begin with a diluted sodium hypochlorite solution, they can enact the protocols. Global health's chlorine supply is thus never 'chained', metaphorically or otherwise. Chlorine, found in a variety of compounds and solutions, is regenerated by a variety of relations at a variety of scales.

In a health center in northwestern Managua, Dr. Muñoz makes his own bleach. He uses salt, water, and electrodes to render sodium hypochlorite. To do this, he has colonized a small space in a garage on the grounds of the health center. His bleachmaking is ad-hoc and off the books. Dr. Muñoz doesn't get extra money or time from his employers at the Nicaraguan Ministry of Health to perform this chemical labor. Still, several weekends a year, he loads a bucket of homemade disinfectant into the health center's ambulance and plies the surrounding *barrios*, handing it out by the plastic bagful. A skillful gift-giver, he carefully calibrates the dilution and hence the intensity of his relationships. Bleach, like abate, demands care. Too much can be dangerous, too little can be ineffective.

Like abate, bleach is a biosecurity intervention, and like abate, it subverts the very scalar and species boundaries it is meant to ensure. Bleach mediates the environments of national disease diagnostic laboratories, local households, and global health research centers from Paris to San Francisco. Dr. Muñoz hands out little bags of his homemade bleach in exchange for cooperation: a blood sample for routine malaria testing, a dengue mosquito larval assay, or participation in a vaccination campaign.

Here, we can see a reversal. Whereas the exchange of abate as a gift among neighbors perhaps undermines the neat bureaucratic and biopolitical accounting of people, insects, and spaces, bleach-as-gift enables such bureaucratic and biopolitical work. Muñoz's crafting of bleach in his makeshift laboratory is complemented by the process of creating bleach solutions in official laboratory and clinical spaces. Percentages of dilution and appropriate targets of use for bleach are clearly delineated in WHO guidebooks for everything from influenza testing to routine injections of insulin or saline.

In Nicaragua, barrio residents don't need a doctor to tell them that 'bleach kills germs'. But bleach, like abate, goes two ways. By killing germs for us, bleach also acts as a reminder that they and we live together. As simultaneously lethal and lively technologies, bleach and abate draw Muñoz, the CHWs, and their neighbors into a paradoxical kind of social relation. The distribution of bleach and abate—which occurs at the smallest of scales and in the most carefully apportioned dilutions—instantiates what Heather Paxson (2011) calls 'microbiopolitics', yet where does the chemical sit in relation to bios? Chlorine compounds and organophosphates are certainly 'vibrant matter', but talk of 'life' or its politics oversimplifies the situation (Bennett 2010). In their vitality, chemicals undermine simple life/death, purity/danger binaries. They do not simply put things in and out of place. In scalar terms, they are not just the locally applicable tools of a global project. Bleach and abate are effective as gifts because they have volition. Even with its fundamentally 'basic' (in the chemical and sociological sense) tactility, bleach doesn't stand for itself. Its symbolic name, NaClO (temephos's name is $C_{16}H_{20}O_6P_2S_3$), is the story of a precarious, but structured, relationship. That relationship must be re-established—bleach must be given its social power—in embedded processes of communication and signaling. These aesthetic processes point to what I am calling 'sensory leakage.'

SENSORY LEAKAGE

Doña Feliciana, a Nicaraguan health inspector, is in charge of confirming the presence of chlorine in her local water supply. She sets out four times a year with litmus strips and a color scale to ensure that the gas (which goes by the name *cloro*—also Spanish for 'bleach') has

penetrated the infrastructure to make water potable. She dribbles water from faucets and hoses onto her strips and, squinting in the sunlight, holds them up to the color scale.

"Is this pink, or red?" she asks the ambulance driver who is chauffeuring her from site to site.

"For me, that's red," he says.

Red is no good. She needs pink. Still, she matches the color to a pH value and marks it down on a bureaucratic record sheet not unlike the one used by the CHWs to document their distribution of abate. At this point in the water supply, chlorine is present, but not in the right way. Like the CHWs who manipulate and account for abate, Doña Feliciana finds herself materializing a global model for health that is based upon assumptions about chemical reactions. Through the water and the litmus paper, chlorine's presence (in the right form) signals the absence of fecal coliforms and other harmful but invisible things.

Like the CHWs, Doña Feliciana is enacting several kinds of locality at once (Yates-Doerr 2014). She notes a location in time: the position of this test relative not only to that of the last test but also to that of the last reported breach of water quality. She is accounting for a point in geographical space. And she is attesting to the infusion of an entire infrastructure—a distributed, fluid space—with a chemical. Only by simultaneously pinpointing bleach and affirming its diffusion can she make her sector of the municipal grid fit a global ideal of 'potable water'—the very potable water that is the medium for abate.

In Doña Feliciana's accounting for water quality, aesthetics come before numbers. What is primary is the relationship between the strips and the water, rendered in pH, or 'potential hydrogen'. Yet that relationship can only be enumerated after it is rendered on a sensory color scale. Potential hydrogen thus comes to Doña Feliciana through diffraction: not a direct

representation of difference, but a sense, or aesthetic signal, of the effects of difference (Barad 2007).

The ethical and technical weight on Doña Feliciana's shoulders is heavy. She must read the color scale as closely as possible, because chlorine, like abate, must be distributed in controlled quantities. She must be cautious in her readings because any inaccuracy could mean either poisoning or infection. Her embodied reading of the scale thus not only measures water quality, it senses water quality. Her body, the color scale, the pipes, and the liquid medium are bound together. Water's material content and the health worker's aesthetic sense, like body and chemical, leak into one another (Helmreich 2011; Heyward 2010; Haraway 2008; Barad 2007).

Abate is also known through sensory leakage. The closet at the Managua health center where Dr. Muñoz stores his abate is ripe with the odor—a sulfurous, vaguely fecal smell. Spend a few moments in this confined space, and you begin to feel the drift of the chemical vapor into the sinuses and lungs, and eventually upward and downward. Headaches and nausea result from this leakage, further reminders that abate is a chemical weapon. CHWs are warned not to lose the small plastic spoon that comes with their equipment package. Otherwise, they will find that their hands eventually start burning as the abate granules dissolve through sweat glands.

In her description of a North American chemical infrastructure, Murphy calls attention to the integral role of sensation:

> Many different disciplines and communities of experts make knowledge about chemical infrastructures, but in piecemeal ways—some experts study chemicals in fish, other experts engineer smoke stacks, while others diagnose illnesses. Yet others feel chemical infrastructures by working and living in sites saturated by industrial chemicals. Quotidian

> acts of breathing, drinking, and smelling can become knowledge-making moments in chemical infrastructures (Murphy 2013; see also Murphy 2006).

Global health's chemical infrastructure is also made piecemeal—Doña Feliciana makes the water, Dr. Munoz makes the bleach, and community health workers deliver the abate, all by feel as much as by rigid routine. That infrastructure, however, relies upon acts of *un*feeling as much as of feeling.

Usage guidelines for Skeeter 1% —written in English on the packages Nicaraguan health centers receive—clearly state that respiratory and skin protective equipment should be used at all times by those who work with the chemical. These warnings mean little in Nicaragua, and not just because they are in English. While complaints about upset stomachs and headaches permeate the CHWs' conversation on breaks and outside work, during the *jornadas de abatización*, talk of injury is muted. The words *el abate me pica* leaked out during quiet conversations or in post-hoc interviews, or over shots of rum and bowls of *vigorón* served at the parties the community health workers held at the end of each campaign, scrounging leftover money to mark the job's completion. The protocol for eliminating mosquitoes, after all, depends upon acceptance of the notion that abate, properly distributed in the environment, is not harmful to people. There is a technical and ethical weight to these aesthetic judgments, too, but in this case that weight is even more clearly gendered. In much of Nicaragua, the work of abatización—which takes place mostly in the intimate spaces of homes—is performed by women CHWs. Conversations about mosquito breeding sites tend to take place among women, and clandestine exchanges of the chemical after the campaigns are a "traffic between women" (Roberts 2012: 168). A painful kind of local biology emerges here. A global health project here

exacerbates gendered differentiation even as it attempts to intervene in a presumably standardized body and environment (Lock 2013).

Like Doña Feliciana, the CHWs find themselves in a chemical 'double-bind' (Fortun 2001). Their work materializes standardized ideas about the vulnerability of bodies to dengue, even as it produces bodily vulnerability. Individual exposure is, paradoxically, a pathway to population protection. In dengue prevention, temephos is both a tool for treating potable water and a chemical with 'no residential use' (EPA 2001). As Kim Fortun argues in her analysis of chemical exposure and those who attempt to publicly represent it, double-bind situations "[provide] a lens for observing experiences produced by established rules and systems, yet not adequately described in standard explanations of how those systems function and change" (2001:13). Seen as leaky things, standards (both global and local) for chemical safety and efficacy do not clash due to differences in language or concepts; rather, they seep into one another through injuries to the bodies of people and insects.

Yet the effects of sensory leakages are not all injurious. Chlorine and abate both do good work on and around Nicaraguan bodies. Even as they endured the dizziness and nausea induced by abate, women and men CHWs found that working with the organophosphates made their fingernails harder and smoother. This made their hands into better canvases for inexpensive nail polishes. No one would admit that this particular bodily-chemical leakage amounted to a fair trade for low pay and upset stomachs, but it did matter. Like most parents in Nicaragua, CHWs washed the skins of their children's fruits and vegetables in a light bleach solution, knowing that ingesting a bit of cloro was preferable to ingesting the eggs of a worm or a parasite.

Down the road from Dr. Muñoz's lab, Gertrudis cleans houses for a living. She thinks through the presence and absence of dirt with her nose, her eyes, and her hands. She calibrates

the mix of water and cloro appropriate for scrubbing a tile floor to that which is appropriate for whitening socks and tee shirts. Bleaching is about working the budget, and about being patient. Shades of white matter. Not all cloros are created equal. If you've got the money, Clorox is better than the kind they ladle into plastic bags. Bleach is artifice all the way down, from the electrolysis of salt and water, to application on floors and dishes to kill *microbios,* to dyeing school uniforms (stained whites are grounds for punishment).

As an aesthetic practice, chemistry remakes the body in manifold ways, just as it remakes the world, for better and for worse. It "deals with combinations of elements that conserve some identity while associating and dissociating" (Stengers 2011: 51). The work of health is more than simply the action of humans on objects, or vice versa. Local biology happens as inorganic chemicals become entangled with organic life on the living/dead limen marked by skin, fingernails, and hair, enabling particular kinds of relationships and feelings.

CONCLUSION

The social lives of global health chemicals usually begin in neat models: efficacy estimates, distribution protocols, usage guidelines, and production standards. These models are important, but incomplete, components of chemical infrastructure. As Stefan Helmreich (2011: 138) argues with reference to the 2010 Gulf of Mexico oil spill, the 'empiricity' of global events only becomes manifest when models go into action. His examples include climate models and disaster simulations. Well before the spill, theoretical ideas about the nature of water and oil were mobilized by experts, governments, and on-the-ground actors who engineered blowout preventers, offshore rigs, and chemical dispersants—the stuff of petrochemical infrastructure (see Appel 2012). In the construction of these things, ideas about the relationship between

seawater and oil were materialized. In the 2010 Deepwater Horizon disaster, such ideas were put to the test and (theoretically) refined.

My examination of the numerical, structural, and sensory leakages of abate and bleach in Nicaragua shows that one way of tracking the empiricity of global health problems might be to ask how theoretical ideas about chemicals become materialized in an analogous manner. Epidemiological, entomological, and economic models calculate the costs of chemicals, the rate of nonhuman death they will cause, and the number of, as the Bill and Melinda Gates Foundation puts it, 'healthy, productive [human] lives' that will result.

To turn global health into a material reality, projects must enroll a variety actors, from clinicians to citizen advocacy groups to CHWs to laboratory technicians. Chemicals and other forms of medical infrastructure (stethoscopes, personal protective equipment, clinical procedures) give these actors a common way of relating to patients, as well as to unseen microbes and myriad mosquito larvae. But infrastructures are not sealed environments. Even as they make demands on people to interact with one another in prescribed ways, they leak (Anand 2011; Bowker and Star 1999). In this article, I have extended Lock's (1993) notion of local biologies by examining Nicaraguan engagements with two 'leaky things', chlorine and organophosphates. In global health, these chemicals figure in standardized models about how to manipulate a (theoretically) standardizable body and environment. Their material qualities are integrated into these models. A certain amount of abate (theoretically) kills a certain amount of mosquito larvae over a certain period of time. Yet as abate leaks into water, soils, and skins, new kinds of relationships emerge. Bodies get sick. Insects become resistant. Clothes get whiter. Nails get harder. *El abate me pica.* An intervention model, put into practice, engenders new, empirically observable things, which themselves also leak.

A focus on leakages provides important insights into the interface between material and social vitality. Rather than conceiving of chemicals as powerful political actors in their own right (cf. Bennett 2010), I have focused on how they fit into openings in social structures caused by chronic epidemic states, even as they bore into the thresholds of buildings, pipes, and other elements of urban planning, where infection is often seen to lay in wait. The properties of chemicals, as kinds of "informed materials," change once they are released into "everyday reality" (Barry 2005: 57).

A concern for the worlds created by chemical interventions helps us understand how global health plays a role not just in surveying (and supposedly improving) bodies, but in shaping biologies. The era of global health is increasingly a response to life in that other chemically saturated 'global' era (the one now commonly called 'Anthropocene'). Indeed, the sense of a need for a global approach to health arguably exists because of an industrial ecology that is enveloping the nonliving world more firmly than ever into the living one, creating new possibilities for chemical harm (Murphy 2013; Fortun 2012). At stake in the critical study of chemical infrastructure, then, is a fuller understanding of how differently situated actors make ethical decisions in sites where bodily and environmental conditions seem ever more entangled. These are the sites where, as Brown and Kelly (2014) put it in their analysis of disease 'hotspots' such as West Africa's Ebola zone, social proximity and social distance appear to be collapsing. While leakage is a convenient way to identify failings in the infrastructures of global health and local planning, in this article, I have outlined three ways—numerical, structural, and sensory—in which leakage is also a mechanism through which people refigure standardized models of action to address the demands of both an urgent present of epidemic disease and an uncertain future of

chemical afterlives. If chemical leakages are where global health and local biologies meet, then they might be thresholds to meaningful forms of engagement and feeling.

Chemical leakages are thresholds to engagement, but they are not hard endings (Koch 2013). To illustrate this point, let me return to the case, mentioned above, of epidemic kidney disease among Nicaraguan sugar plantation workers. This epidemic continues to be popularly associated with the increased usage of chemical pesticides. In 2006, suspicion that chemicals caused kidney failure was at the heart of a series of legal cases, protests, and media campaigns by Nicaraguan plantation workers and environmental activists. This agitation, rather than epidemiological surveillance, ultimately brought the disease to the attention of the World Bank. Knowledge about failing kidneys continues to leak back and forth between the health, legal, and transnational advocacy sectors, challenging the traditional primacy of medicine in global health advocacy.

As it turns out, however, a link between kidney disease and pesticide residue in the water that sugar plantation workers drink has not been proven. It seems just as likely that increased exposure to heat (cutting sugarcane is incredibly hot, dehydrating work) is to blame for failing kidneys (Brooks, Ramirez-Rubio, and Amador 2012). While it is satisfying in some ways to see chemicals as a 'magic bullet' explanation, this story reveals a more complicated situation. In a similar way, while it's tempting to think of a chemical intervention—whether a drug or a pesticide or bleach—as a magic bullet solution to a health or hygiene problem, attention to leakage—as both metaphorical and material process—reveals that there is no magic in individual things.

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NOTES

[1] World Wide Web searches are, of course, also locally contingent: results vary depending on one's IP address location. This particular search was conducted from a computer terminal in France in 2014. Thanks to an anonymous reviewer for pointing this out.

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